The recent renovation of St. Patrick’s Cathedral in New York City—a prominent 1870s religious landmark designed by James Renwick Jr. and last modernized in 1949—reflects the vision of its trustees to advance not only ecological and economic value, but also social values held closely by “America’s Parish Church,” as it is known.

As the leadership told The New York Times, this centerpiece of the Archdiocese of New York would maintain its historic fabric even as major systems were upgraded and as the 138-year-old building “was going green.”

The project team, led by MBB Architects, included more than 25 consultants, engineers and specialists that directed a restoration of every square inch of historic fabric, employing the highest levels of preservation treatment and techniques. Design innovations were developed by the project team—including hidden stone tracery structure, a unique means of venting stained-glass—and
new mechanical systems including a 10-well geothermal plant were threaded seamlessly through the building. Strategic architectural interventions, such as a soaring, minimalist glass wall dividing the main sanctuary from the Lady Chapel, enhance worship and functionality. Modern glass doors and improved architectural elements have created an energy-saving enclosure that enhances visitor comfort and views of historic interiors, stained glass, and structures.

The renovations improve material strength and durability, and the new HVAC system has replaced an inefficient array of steam radiators and 1960s-era condensers. On a pure performance level, St. Patrick’s Cathedral’s ambitious campaign of upgrades, retrofits and sensitive modern interventions have led to a 30% reduction in annual energy use. The work also stabilizes and protects significant historic fabric in a widely beloved religious destination that welcomes 5 million-plus visitors each year.

**Big Legacy, Big Plans**

The work on St. Patrick’s Cathedral took 11 years and, ultimately, about $177 million to transform a city block-sized campus of Gothic Revival architecture and park-like greenery. Formerly failing marble, plasterwork, and stained glass were in dire need of preservation measures to stabilize and improve the complex’s original fabric. The last full restoration of St. Patrick’s Cathedral occurred in the 1940s, with limited resources. In the more recent work, historic details and elements, long concealed or forgotten, have been restored or recreated with studied deference to Renwick’s neo-Gothic details and design intent.

New, unobtrusive glass doors at historic bronze portals on Fifth Avenue offer a metaphor for rejuvenating St. Patrick’s Cathedral, and improve enclosure performance while also opening its arms in a welcome for neighbors and millions of visitors. This is among the many architectural and engineering interventions designed to enhance visitor experience, yet create a minimalist intervention seeking to carefully integrate new systems into the historic fabric. New fan-coil units, for example, were custom-designed to fit within existing radiator enclosures.

Most evident in this regard is the quiet, low-impact geothermal system—among Manhattan’s largest ever—which obviated noisy, visible exterior cooling equipment and allowed for a more efficient use of space. The new system supports a variety of improvements focused on occupant comfort, and it mitigated local noise and pollution in Midtown Manhattan. The geothermal wells reach a depth of 2,200 ft into Manhattan’s bedrock to draw groundwater for heating and cooling—that’s
Local Ecosystems
The renovation of St. Patrick’s Cathedral enriches local ecosystems. Working with landscape architect RKLA, the geothermal plant well drilling and the laying of horizontal pipe became an opportunity to restore existing plant beds that had become overgrown and poorly-drained over time. After drilling the geothermal wells, the city block-sized site’s perimeter gardens and plant beds were redesigned, adding new native plantings including blooming species, berry shrubs, and seven mature Columnar Hornbeam trees alongside new bluestone walkways and curbs.

The new soils and native plants better serve the city’s insect and animal life, offering varied seasonal blooms and even fruit production—a real long-term ecological restoration. Tree canopy now covers 40% of the garden area, which along with fountains now attracts sparrows, warblers and robins, often found (and heard) in the branches of the amelanchiers and cherry trees. About 60% of shrubs, perennials and groundcovers have either berries, nuts or seeds, attracting more songbirds and squirrels. The increased site vegetation contributes to stormwater management, reducing runoff, and the suitability of the plants to the...
local climate reduce the need for irrigation.

Other updates have improved the water and plumbing systems, offering a model for existing urban religious buildings to conserve water use and related resources. These include:

- Installing the closed-loop geothermal and mechanical system;
- Restoring the landscape and habitat; and
- Reducing domestic water demand.

By converting from utility-provided steam to geothermal, the systems eliminate condensate wastewater inherent in steam production. The no-bleed, closed-loop system...
CASE STUDY  ST. PATRICK’S CATHEDRAL

BUILDING AT A GLANCE

Name  St. Patrick’s Cathedral
Location  Fifth Avenue and 51st Street
Owner  Trustees of St. Patrick’s Cathedral
Principal Use  Cathedral, place of worship
Employees/Occupants  Pews seat 2,300 people, 5 million visitors per year
Percent Occupied  100%
Gross Square Footage  40,000 (interior)
Distinctions/Awards  2019 AIA Cote Top Ten Award; 2018 Chicago Athenaeum American Architecture Award; 2016 AIA National Honor Award; 2016 AIA New York City Merit Award; 2016 AIFRAA/Faith & Form; 2016 MAsterworks Best Restoration Award; 2016 NY Landmarks Conservance Lucy Moses Award

RENOVATIONS

Year Built  1858–1888, opened 1879
Major Renovation  2017
Total Renovation Cost  $177 Million
Renovation Scope  Preservation of exterior and interior surfaces—marble, slate, metalwork, ornamental plasterwork, decorative woodwork, cast stone, and stained glass—as well as the seamless insertion of sustainable systems, including a fire suppression mist system, new audio-visual equipment and geothermal heating and cooling system. The project extended to renovation of the Rectory and expansion of the Parish House; upgrades to the campus landscape accommodated hidden infrastructure while creating new garden and terrace designs.

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site)  66 kBtu/ft²
Electricity (Grid Purchase)  56 kBtu/ft²
Natural Gas  10 kBtu/ft²
Annual Net Energy Use Intensity  66 kBtu/ft²
Annual Source (Primary) Energy  186 kBtu/ft²
Annual Energy Cost Index (ECI)  $0.97/ft²
Carbon Footprint  11.6

Design innovations were developed by the project team to stabilize and improve the historic building enclosure, including hidden stone tracery structure, and a unique means of venting stained-glass windows.

PROJECT TEAM

Building Owner  Trustees of Saint Patrick’s Cathedral
Owners Representative  Zubatkin Owner Representation
Architect  MBB (Murphy Burnham & Buttrick Architects)
Construction Manager  StructureTone Inc.
Historic Preservation Consultant  Building Conservation Associates
MEP & Geothermal Engineer  Landmark Facilities Group, Inc.
Structural Engineer  Silman
Civil & Geotechnical Engineer  Langan Engineering & GB Geotechnics USA Inc.
Geothermal Consultant  P.W. Grosser Consulting
Mechanical Subconsultant  Lane Associates
MEP Acoustics Engineer  Cerami & Associates
Landscape Architecture  Robin Key Landscape Architecture
Stained Glass Preservationist  Jean Phifer, FAIA, and Drew Anderson
Lighting Consultant  Fisher Marantz Stone
Fire Prevention Consultant  Arup Fire
Energy Consultant  Northeast Energy Services
Geothermal Well Drilling Engineer  Samuel Stothoff Company
Glass Consultant  Eckersley O’Callaghan & Partners
Glass Consultant  Heintges & Associates
Commissioning  Aramark
Construction Specifications  Aaron Pine
Cost Consultant  Christopher Slocum
Code Consultant  William Dailey
reduces makeup water requirements, saving 1.3 million gallons of water per year and minimizing impacts on groundwater, achieved by a dedicated chiller cooling wells during peak demand. Inside the cathedral, conservation measures include 18 low-flow toilets. Along with the choice of modular chillers and the decision to eliminate a cooling tower, less water is now required for domestic usage and mechanical system makeup.

Respecting the existing historic structures, the geothermal system wells are located in terraced areas and piped through the undercroft and an unused crawl space, increasing their utility and mitigating the need to expand new mechanical enclosures. Another way to preserve the historic fabric is seen in the new fan coils, built into existing radiator covers with custom grilles or ducted to the cathedral’s triforium. New HVAC ducts built into millwork during restoration protect original detailing, with care to allow for ready access and maintenance.

First Costs and Energy Impacts

Overall, the MEP upgrade has reduced the mechanical system footprint, opened up interior space, and modestly but significantly increased availability and use by churchgoers and the public. Other financial impacts have helped the Cathedral to control initial costs and life-cycle costs. For example, the project team reduced first costs through careful construction sequencing and use of a rolling scaffold for the work on ducts and restoration of stained glass and the ceiling. This effective method kept the Cathedral open and its nave clear for people as it also reduced scaffolding expense.

Like many historic cathedrals, this landmark’s uninsulated masonry structure and leaky fenestration presented opportunities for leveraging passive design. Unlike others, however, its unusually high use intensity meant that every improvement had to accommodate St. Patrick’s Cathedral’s millions of visitors and open-door policy—6:30 a.m. until 9 p.m. daily. Clearly, the project team needed creative conservation strategies and responsive energy system designs.

Impacting operational costs are the comprehensive installed sensors, controls and predictive monitoring that serve the MEP plant and geothermal wells. Architectural improvements anticipated ongoing costs, and included:

- Envelope tightening, reducing thermal loss and moisture movement;
- The mechanized glass entry doors, minimizing air infiltration and conditioned air loss;
- Restoration of 3,200 stained-glass windows—and the installation of high-performance protective glazing—boosting envelope U-values and interior comfort;
- Application of thermally performative laminated protective glazing on repaired, re-grouted historic stained glass;
- Weather-stripping and repairing of all original doors; and
- High-efficiency new LED lighting fixtures and low-flow plumbing.

In addition, client leadership favored conversion to electrical systems for sourcing green utility power. Designed for long life cycles, the MEP and other system reconfigurations minimize future interventions, for example by using titanium plates for modular heat exchangers. The modernizations make use of shorter pipe runs for efficiency and eliminate exposed piping and ducts that may cause leaks or necessitate future upgrades. As for the geothermal assemblies, they use only stainless-steel pumps with HDPE ground loop, enhancing durability and mitigating corrosion. The overall redundant, modular equipment approach with options for retrofit or reuse protect against climate swings, maintenance downtime, occupancy changes, and other potential challenges. Modeling of the climate changes and energy economics, in addition, helped ensure optimal sizing and adaptation capacity of equipment and geothermal investments.

With the geothermal system and envelope U-value improvements cutting operational energy needs, the projected energy use intensity (EUI) of the renovated facility is
Historic cathedrals present challenges for improving flexibility and functionality for their dynamic communities, including preservation requirements, original materials and methods, and traditions of use.

**Exceeding in All Requirements**

The modernization and conservation methods for St. Patrick’s Cathedral in New York City had to exceed code and safety requirements to meet the client’s requirements to ensure stable operations and environmental controls in periods of maximum use.

**Expanding Use**

The renovations helped expand use of the sanctuary and Lady Chapel. Overall occupancy capacity increased by 25% through augmented egress routes and the modification of existing doors to serve as egress. By establishing a fire warden program, historic bronze entry portals are now egress designated. In addition, by enclosing the Lady Chapel in structural glass has created an intimate, quiet worship space that better serves the need for smaller services and other religious events.

**Looking to the Future**

To boost resiliency of the facility, which is open year-round, new geothermal and mechanical systems are sized for future extreme weather and potential program expansion. Many solutions are redundant and modular, easing upgrades and reuse.

The MEP systems designs also improve service clearances and consolidate access for operations and maintenance personnel. Redundant chillers and boilers provide new backup. In this way, St. Patrick’s Cathedral is more prepared for weather changes, energy swings, future expansion and new types of use.

Increased tour and programming capacities now provide outdoor access into a new memorial garden, offering a contemplative garden setting for repose.

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66 kBtu/ft²·yr, an improvement of 29% over its 2006 pre-renovation EUIs. Providing all Cathedral heating and cooling without backup use, the compact geothermal system’s post-occupancy reports track 30% annual energy reductions equivalent to 772,211 kg CO₂, with total capacities of 2.9 million Btu/h cooling and 3.2 million Btu/h heating. Post-occupancy reports track anticipated annual energy reductions equivalent to 772,211 kg CO₂.

**Wellness and Uplifted Spirits**

Of equal interest to the Archdiocese of New York, of course, was a world-class experience for worshippers and visitors. The retrofit of engineered systems intentionally optimizes IEQ and user experience for both staff and the public. The new glass entry doors, for example, cut outdoor noise by 80% and reduce drafts, and infiltration of outdoor pollutants including vehicle exhaust. They increase available daylighting in the narthex while improving thermal comfort overall.

The restored stained-glass windows enhance historical appreciation, too, as they increase daylight penetration into the interiors. The work added new skylights to replace roofed-over openings that dramatically boost daylighting at the Cathedral’s side aisle chapels. Acoustical improvements include new engineered systems and partitions, including the structural glass chapel wall. New sound equipment, hearing loop, and restored organ improve audibility for the visiting public. The improved sound transmission coefficient (STC) from envelope upgrades, laminated protective glazings, and the quiet geothermal HVAC operations further enhance the use of St. Patrick’s Cathedral for sermons, tours and performances.
The work has had a valuable impact. Enhancing St. Patrick’s Cathedral’s humanistic responsiveness, glass doors and partitions improve community connections, invite first-time visitors, and boost visitor experience. The Cathedral’s post-occupancy performance includes its largest attendance ever, including the 2015 visit of Pope Francis. St. Patrick’s Cathedral’s staff expanded programming and has been able to lead more informational tours about the challenges of restoring historic churches and

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**Figure 3 MAJOR RENOVATIONS TO ST. PATRICK’S CATHEDRAL**

- 1. Fan Coil Units in Existing Radiator Cabinets
- 2. Restored Gardens Over Geothermal Wells
- 3. New Skylights
- 4. Mechanical Plant Below New Terrace
- 5. Restored Stained Glass
- 6. Glass Entry Doors
- 7. Geothermal Well Heads
- 8. Nave
- 9. Green Roof
- 10. Lady Chapel Glass Walls

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Advertisement formerly in this space.
Key Sustainable Features

Water Conservation
Three design elements conserve water and related resources: a geothermal system using a no-bleed strategy; the landscape and habitat; and domestic water demand.

By converting from utility-provided steam to geothermal, the systems eliminate condensate wastewater inherent in steam production. A no-bleed geothermal and closed-loop hot/chilled water system reduces makeup water requirements and minimizes impacts on groundwater, achieved by a dedicated chiller cooling wells during peak demand. Installation of the geothermal well field required removal of two planting areas adjacent to the Cathedral marked by compacted soils and dense ivy matting.

With the system in place, new planting areas added absorbent soils and native plantings and trees consistent with local hydrologies that absorb runoff from adjacent hardscape and require minimal irrigation. A utility enclosure’s 600-square-foot green roof further improves stormwater management. Interior conservation measures include low-flow toilets and water restriction valves. Along with the choice of modular chillers and the decision to avoid reliance on a cooling tower, nearly 3.8 million gallons of process water are conserved yearly.

Recycled Materials
For sustained long-term performance, durability, and adaptable, resilient uses, the Cathedral modernization sensitively weaves in high-performance systems allowing expansions and 50-year-plus life cycles. Renovations increase mechanical capacity with less energy and equal building area, boosting usability and flexibility of cathedral spaces. Original materials and methods, and reuse of existing enclosures, serve both preservation and environmental goals. Designed for long life cycles, system reconfigurations minimize future interventions by using more durable materials and joining methods, such as titanium plate frame heat exchangers.

A redundant, modular equipment approach with options for retrofit or reuse protect against climate swings, operational downtime, occupancy changes, and other potential. The geothermal systems use only stainless-steel pumps with HDPE ground loop, enhancing durability and mitigating corrosion.

Daylighting
Renovations optimize user experience for church staff and visitors. Occupant surveys document improved comfort and satisfaction, particularly for daylighting, thermal comfort, and acoustics. New glass entry doors cut outdoor noise by 75% and reduce stack effects, drafts, and infiltration of outdoor pollutants including vehicle exhaust. They increase available daylighting in the narthex while improving thermal comfort overall. Restored stained glass increases daylight penetration. New skylights replacing roofed-over openings boost daylighting in side aisles significantly.

Transportation Mitigation Strategies

Community Minded Design
New glass doors at historic bronze portals on Fifth Avenue offer a metaphor for rejuvenating St. Patrick’s Cathedral: improving envelope performance while also welcoming neighbors and visitors. Open throughout construction to accommodate visitors and 18 masses every week, the phasing and construction methods employed helped enlighten the public on the work’s scope and impact, even during the papal visit.

Architectural/engineering interventions focus on enhancing visitor experience, minimizing impact through careful integration into historic fabric, such as new fan-coil units sized to fit existing radiator enclosures. Serving 5 million visitors annually, the site’s high Walk Score (99) and Transit Score (100) minimize the carbon footprint of this traffic. The project improves occupant comfort, reduces total emissions and energy use, and mitigates the infiltration of noise and pollution.

The quiet, low-impact geothermal system—among Manhattan’s largest ever—is a minimally obtrusive option that promotes efficient use of space and high dollar value per square foot. Enhancing the Cathedral’s humanistic qualities, glass doors and partitions improve community connections and invite visitors inside.

Extensive community awareness campaigns sought worldwide feedback and donations. Leadership and parishioner feedback informed design decisions. Local officials, including Landmarks Preservation Commission, supported ideas including geothermal to preserve historic fabric.

cathedrals—including for government agencies, utility companies, property owner-developers, and institutions such as Trinity Church Boston and Westminster Abbey. Fodor’s has called it a “best place to visit.”

Offering valuable post-occupancy lessons for making historic places effective, relevant and resilient, the wide-ranging conservation and retrofit improvements to St. Patrick’s Cathedral create sustainable building systems and functionality, with a focus on long-term, change-ready solutions. In this way, leadership invested in not only “the most sustainable, cost-effective, long-term options,” but also those “that best align with the greater good of the city, community and earth—not just today, but for generations to come.”

ABOUT THE AUTHOR
Jeffrey Murphy, FAIA, is a partner at MBB (Murphy Burnham & Buttrick Architects), an international architecture firm based in New York City.